AUG 2 7 1998

83-B-4

A13.79:SO-345

United States Department of Agriculture

Forest Service

Southern Forest Experiment Station

Research Note

SO-345
May 1988

Competition Impacts on Growth of Naturally Regenerated Loblolly Pine Seedlings

Michael D. Cain

SUMMARY

Intensive competition control was used for 3 years in a naturally regenerated, even-aged stand of loblolly and shortleaf pines (*Pinus taeda* L. and *P. echinata* Mill.) in southern Arkansas. Treatments included: no competition control, woody competition control, herbaceous competition control, and total control of nonpine vegetation. Control of herbaceous vegetation resulted in statistically significant pine growth gains in height, groundline diameter, and volume per tree. Control of only woody competition did not improve pine growth compared to untreated checks.

Additional keywords: Herbaceous competition control, herbicides, *Pinus taeda* L., *P. echinata* Mill., woody competition control.

INTRODUCTION

When properly planned, natural pine regeneration is a viable management alternative to artificial regeneration for restocking pine sites and can be particularly attractive to private, nonindustrial forest landowners because the cost of stand establishment is lower (Williston and Balmer 1974). On cutover areas, natural regeneration of loblolly and shortleaf pines (*Pinus taeda* L. and *P. echinata* Mill.) is considered successful if density averages at least 1,500 seedlings per acre at the end of the first year of establishment, or 700 per acre at the beginning of the third year (Grano 1967), and milacre stocking is at least 60 percent (Trousdell 1963). Even so, there is increasing evidence from research in loblolly plantations to suggest that competing vegetation can cause substantial loss in pine growth during the first 5 years following establishment (Haywood and Tiarks 1981, Nelson and others 1981, Knowe and others 1985, Tiarks and Haywood 1986, Zutter and others 1986, Miller and others 1987). This study was conducted to investigate the interrelationships among woody and herbaceous competition components and to assess the impact of these competition components on establishment, survival, and growth of naturally regenerated loblolly and shortleaf pines.

METHODS

Study Area

The study is located on two 5-acre clearcuts within the Crossett Experimental Forest in southern Arkansas. Prior to clearcutting, these areas contained uneven-aged stands of loblolly and shortleaf pines that ranged up to 28 inches in d.b.h. with about 100 pines per acre and about 9,000 fbm (Doyle scale) saw log volume per acre. Hardwoods that were 1 inch and larger in groundline diameter (g.l.d.) were stem injected in the summer of 1980 with herbicide. Prescribed burning with backfires was done in the winters of 1979 and 1980.

A seed tree regeneration cut in the spring of 1981 left five seed pines per acre. In August 1983, the 3-year-old rough was mowed with a Hydro-ax® to a height of about 2.5 feet, above established pine seedlings, to insure a uniform treatment area. Seed trees were removed immediately after mowing.

Soils are Bude (Glossaquic Fragiudalf) and Providence (Typic Fragiudalf) silt loams. These soils are usually wet in winter and dry in summer and have a site index of 85 to 90 feet for loblolly pine at age 50.

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Study Establishment and Treatments

Sixteen treatment plots measuring 104 by 104 feet (0.25 acre) were established in the fall of 1983 using a randomized, complete block design with four replications of four treatments. Interior measurement plots were 66 by 66 feet (0.1 acre), and each plot contained 10 systematically established, permanent milacres for data collection.

Four competition control treatments were initiated during the 1984 growing season and were maintained as follows:

Check—Untreated mixture of woody and herbaceous vegetation that invaded the study areas following removal of the midstory and overstory pines and hardwoods. The 3-year-old rough was mowed in August 1983 with no additional treatment.

Woody control—All standing and sprouting hardwoods, shrubs, and woody vines were controlled annually by singlestem treatments with herbicides.

Herbaceous control—Forbs, grasses, weeds, and vines were controlled annually using pre-emergent and postemergent herbicides.

Total control—A combination of herbicides was used annually to control all nonpine vegetation.

Measurements and Data Analysis

Competition levels of woody and herbaceous species have been assessed annually in late summer to document the degree of treatment success. Woody rootstocks were counted by species and by 1-foot height classes on each milacre. Percent ground cover of herbaceous vegetation (grasses, forbs, vines, and semiwoody plants) was determined by ocular estimation to the nearest 10 percent within each milacre. Herbaceous genera that covered more than 15 percent of a milacre were recorded.

Prior to treatment and annually at the end of each treatment period, pine seedlings were counted on each of the 10 milacres per plot for calculation of density and percent stocking. In addition, 50 pine seedlings—principally loblolly—on each plot were randomly selected, tagged for identification, and measured at the end of each growing season for total height (to the nearest 0.1 foot) and g.l.d. (to the nearest 0.04 inch).

Analysis of variance was used to evaluate treatment differences in competition and pine survival, stocking, and density. Analysis of covariance was used to evaluate pine growth in g.l.d., height, and volume for tagged seedlings using initial g.l.d., height, and volume respectively as the covariates. Mean volumes of surviving measurement seedlings were calculated from: $\bar{\Sigma}$(total height)(g.l.d.)^2. Duncan's Multiple Range Test was used to partition mean differences between treatments. Percent data were analyzed following arcsine $\sqrt{\text{proportion}}$ transformation. These analyses were carried out at the 0.05 level of significance.

RESULTS AND DISCUSSION

Competing Vegetation

After 3 years of herbicide applications, density and size of woody competition and percent cover by herbaceous vegetation were significantly reduced in accordance with treatment definitions when compared to untreated checks (table 1). Although reduced, competing species were not eliminated.

The most prevalent woody competitors across all plots after 3 years of treatment were *Callicarpa americana* L., *Rhus copallina* L., and *Vaccinium* spp. Although these small shrubs comprised 69 percent of all species inventoried, they should become less of a problem in terms of site occupancy once the pines have achieved crown closure. Major recurring tree species were *Acer rubrum* L., *Diospyros virginiana* L., *Quercus falcata* Michx., and *Sassafras albidum* (Nutt.) Nees, but these four species accounted for less than 15 percent of the total hardwood density. The remaining 16 percent of all woody stems was divided among 17 other species at the end of 3 years of treatment.

The most prominent herbaceous vegetation types after 3 years were grasses and vines, regardless of the degree of competition control. Milacre stockings of the five predominant herbaceous genera in the fall of the third year of treatment were: *Lonicera japonica*

Michael D. Cain is research forester, Forestry Sciences Laboratory, Southern Forest Experiment Station, Forest Service—USDA, Monticello, AR, in cooperation with the Department of Forest Resources and the Arkansas Agricultural Experiment Station, University of Arkansas at Monticello. Cooperation was also provided by the Georgia-Pacific Corp.; BASF Wyandotte Corp.; Dow Chemical Co.; E.I. duPont deNemours & Co.; and Monsanto Agricultural Products Co.

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Table 1—*Mean density and height of woody species and percent ground cover by herbaceous species after 3 years of intensive competition control in a stand of natural loblolly-shortleaf pine regeneration*

Treatments	Woody competition		Herbaceous vegetation ground cover
	Density	Total height	
	Stems/acre	*Ft*	*Percent*
Check	10,600a†	3.4a	98.a
Woody control	2,375 bc	2.0 b	99a
Herbaceous control	4,900 b	3.9a	10 b
Total control	75 c	0.6 c	14 b
Error mean square	590	0.4	15

†Within-column means followed by the same letter are not significantly different at the 0.05 level.

Thunb., 79 percent; *Rubus* spp., 78 percent; *Uniola* spp., 64 percent; *Andropogon* spp., 43 percent; and *Smilax* spp., 30 percent. Another 13 herbaceous genera of grasses, vines, forbs, and semiwoody plants were recorded, but they were of less importance overall when compared to the five genera listed above. Although most grasses disappear as fully stocked pine stands mature, shade-tolerant vines such as *L. japonica* can be a persistent problem in pine management (Cain 1985).

Pine Seedling Response to Treatment

When the study was being installed, pretreatment pine seedling density averaged only 1,338 stems per acre with 47 percent milacre stocking. A bumper pine seed crop the winter after the study installation produced an average of 13,000 pine seedlings per acre and 96 percent milacre stocking by the end of the first year of competition control. Pine seedling density generally declined across all treatments through the third year but still averaged over 9,000 stems per acre (table 2) and exceeded the minimum recommended density of 700 stems per acre (Grano 1967) thought to be needed in the third year for successful natural regeneration of loblolly and shortleaf pines on clearcut sites.

Table 2—*Pine seedling density and milacre stocking after 3 years of intensive competition control*

Treatments	Density	Milacre stocking
	Stems/acre	*Percent*
Check	9,350ab†	100
Woody control	5,600 b	85
Herbaceous control	14,000a	100
Total control	8,100 b	95
Error mean square	932	...

†Within-column means followed by the same letter are not significantly different at the 0.05 level.

Milacre stocking of pine seedlings (table 2) after 3 years of treatment was more than adequate for natural regeneration based on published recommendations (Trousdell 1963). By the end of the third year of competition control, the majority of natural pine seedlings ranged in height from 1 to 3 feet for both density and milacre-stocking variables, regardless of treatment.

Height and diameter gains of measurement pines increased each year across all treatments as the seedlings grew above competing species. Nevertheless, pine growth gains were most apparent where herbaceous species were controlled (fig. 1). Statistically significant increases in height and g.l.d. growth during both the second and third years on plots where herbaceous competition was controlled resulted in significant volume gains for measurement pines on both total control plots and herbaceous control plots as compared to pine volume growth on check or woody control plots (table 3). Where only woody species were controlled, there was no significant improvement in pine growth through the third year when compared with pine growth on untreated check plots. Even though herbaceous competition had a negative impact on seedling growth, there was no reduction in survival of measurement pines during the first 3 years of the study (table 3).

One long-term investigation, on sites similar to ones in the present study, showed that small clearcuts of about 5 acres will naturally regenerate with pines that seed in from bordering loblolly and shortleaf seed trees and will develop into well-stocked stands even with low-intensity site preparation and without followup control of competition (Baker and Murphy 1982). In that investigation, however, the imported vine, *L. japonica*, was not yet a problem to successful pine regeneration in the South. In a more recent study, Cain (1985) found that a dense ground cover of *L. japonica* and associated herbaceous vegetation not only reduced growth of naturally regenerated loblolly and shortleaf pine seedlings but

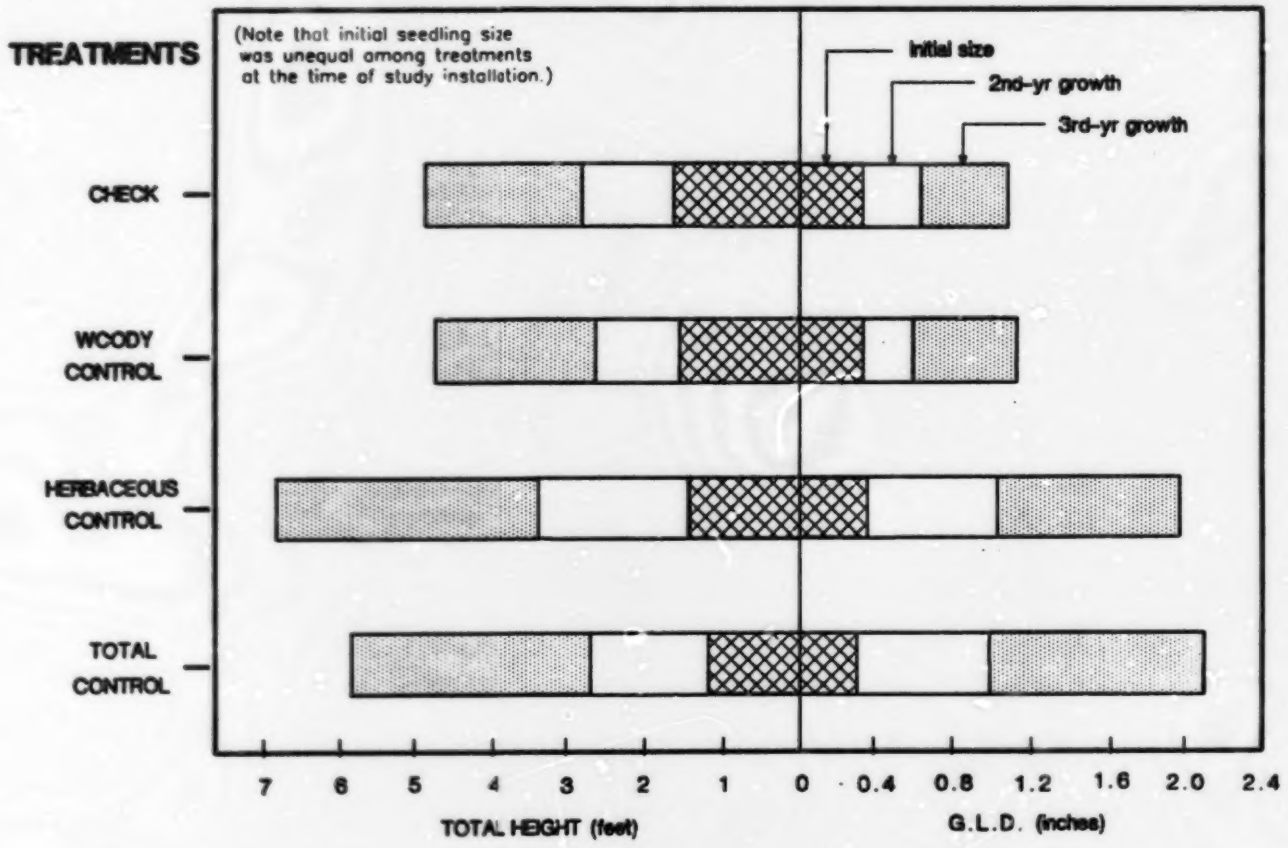

Figure 1.—*Height and groundline diameter (g.l.d.) growth trends for surviving measurement pines by treatment during 3 years of competition control.*

also inhibited pine establishment from natural seedfall. Therefore the type of herbaceous vegetation that is present on an area may determine the degree of control needed for pine establishment and growth.

MANAGEMENT IMPLICATIONS

In managing for natural loblolly and shortleaf pine regeneration, there are at least two circumstances where intensive competition control would be justified from an operational standpoint. Both circumstances are correlated with poor to average pine seed crops.

The first would be where density and stocking of pine seedlings are less than optimum for successful regeneration, and a dense cover of woody and herbaceous vegetation on the site precludes further pine establishment even when a pine seed source is available. In this situation, some form of site disturbance such as temporary control of competition would increase the likelihood that supplemental pine regeneration would occur. For example, at the time that the present study was installed, 3 years after a seed-tree regeneration cut, loblolly and shortleaf pine seedling density (1,338 trees per acre) and milacre stocking (47 percent) were marginal when compared to the recommended levels of 700 trees per acre and 60-percent milacre-stocking. A bumper pine seed crop during the winter of study establishment, in combination with site disturbance (mowing), resulted in high pine seedling density and stocking on all plots, including checks, 1 year later.

The second would be where the pine seed source has been removed from an area, but density and stocking of established pine seedlings are at or somewhat below the recommended levels for successful natural regeneration. In this situation, pine release could be beneficial for the landowner. Intensive control of herbaceous vegetation in the present study, for example, resulted in real growth gains for pine seedlings compared to untreated checks or compared to pines on plots where only woody vegetation was controlled. Therefore such treatments could at least maximize growth of established pine seedlings in understocked stands on sites where

Table 3—*Survival and mean volume growth of 200 measurement pines per treatment.*

Treatments	Third-year survival	Mean volume per tree		
		Initial	2nd-yr growth	3rd-yr growth
	Percent		*Inch*³	
Check	95a†	4a	23a	104a
Woody control	93a	6a	16a	97a
Herbaceous control	98a	5a	63 b	348 b
Total control	93a	3a	63 b	383 b
Error mean square	42	6	366	7,532

†Within-column means followed by the same letter are not significantly different at the 0.05 level.

there is no opportunity for additional natural pine seeding, thereby avoiding the costs and lost time associated with starting over using artificial regeneration.

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* GOVERNMENT PRINTING OFFICE: 1988 - 566019 / 85003